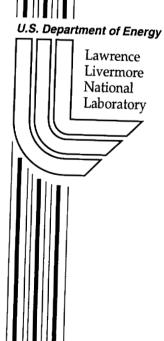# Final Report for "B503962-ATLAS"

J. Dongarra

July 1, 2001

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Final Report for "B503962- ATLAS"

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FINAL REPORT
May 31, 2001

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Under
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Date prepared
July 1st, 2001

Final Report on

LLNL Subcontract B503962
ATLAS

Jack Dongarra

1. Project Overview
   Determining and characterizing the effectiveness of run-time optimization techniques is particularly relevant to modern sparse linear algebra software libraries that tend to hide from the user the internal storage format. For instance, a certain storage structure may dictate a particular algorithmic approach. Once a general scheme of access has been found based on a storage structure, one promising idea involves analyzing the sparsity pattern of the matrix operand to find places where the efficient static optimization techniques may be re-used. There are numerous ways in which this can be done, and it is almost certain that there will be no provably best way. In this case, it will also be necessary to search the space of available options during run-time.

   We have experimented with a variety of techniques for optimizing sparse matrix vector multiplication to take instruction sets, functional units, and memory hierarchies into account on the Power 3 architecture. Sparse matrix-vector multiplication is of course the inner loop in any iterative solver, even multigrid, since it includes all the interpolation, restriction, and smoothing operations. The structural properties of the application leads to sparse matrices that feature a sufficiently regular pattern, so that the automatic optimization techniques already integrated in ATLAS can be successfully re-used and applied to generate the appropriate basic sparse linear algebra kernels needed in many applications. Our plan for achieving the necessary and exceptionally high degree of portability and optimization leverages the experience of our team in developing ATLAS technology.

2. Papers and Book Chapters Supported in Part by the Subcontract:
   1. *Automated Empirical Optimization of Software and the ATLAS Project*, R. Whaley, A. Petitet, and Jack Dongarra, Parallel Computing, Volume 27, Numbers 1-2, pp 3-25, 2001, ISSN 0167-8191.
   2. *Iterative Solver Benchmark*, Jack Dongarra, Victor Eijkhout, Henk van der Vorst, submitted to Scientific Programming, January 2001.

3. Project Highlight
   We participated in the "ASCI ITS Short Course, Power Programming", held at LLNL on May 15th 2000. Clint Whaley, from the University of Tennessee, presented a 1.5-hour tutorial on the "Fundamentals of High Performance Programming". This was tutorial material on how and when to do hand optimization of floating point rich codes, and on how differing architectures require different optimizations.

   We have developed a version of the Linpack Benchmark tuned to the hardware of the ASCI BLUE hardware of the ASCI BLUE Pacific system. It was our goal to produce the fastest implementation that will take advantage of the hardware and software infrastructure on the BLUE Pacific machine in achieving this mark. In order to accomplish this goal, our team has

drawn on the expertise in this field developed with our work on the ScaLAPACK and ATLAS projects. We have been collaborating with researchers at LLNL to produce software for the Linpack benchmark that is fully optimized for the ASCI-Blue Pacific system.

4. Concluding Remarks

I have attached to this email copies of the papers supported under this effort.